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TART96
A Coupled Neutron-Photon 3-D, Combinatorial Geometry Monte Carlo Transport Code

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Abstract

TART96 is a coupled neutron-photon, 3 Dimensional, combinatorial geometry, Monte Carlo transport code. This code can run on **any modern computer**. It is a **complete system** to assist you with input preparation, running Monte Carlo calculations, and analysis of output results. TART96 is also **incredibly FAST**; if you have used similar codes, you will be amazed at how fast this code is compared to other similar codes. Use of the entire system can save you a great deal of time and energy.

TART96 is distributed on CD. This CD contains on-line documentation for all codes included in the system, the codes configured to run on a variety of computers, and many example problems that you can use to familiarize yourself with the system.

TART96 completely supersedes all older versions of TART, and it is strongly recommended that users only use the most recent version of TART96 and its data files.

Acknowledgments

I thank the many users of TART95 and TART96 who have supplied extremely useful feedback to me. Since the release of TART95, in July 1995, the response from users in terms of feedback has been extremely useful in improving the code. These improvements have been in terms of correcting problems in the initial release of TART95, and in terms of proposing new or improved options to meet the needs of users. I highly encourage all users to supply your feedback to me - we can all gain from your experience.

TART96 CD

TART96 is distributed on CD. This CD contains on-line documentation for all codes included in the system, the codes configured to run on a variety of computers, and many example problems that you can use to familiarize yourself with the system.

The TART96 System

This report is intended merely as a brief introduction to TART96. In particular no graphics results are presented in this report. If you havent used interactive graphics before you are only making your job harder and your tasks will take longer to accomplish. The on-line documentation for the TART96 system codes, distributed on TARTT96 CD, has been coordinated to illustrate combined use of the codes to make your job simpler and your work easier to accomplish. **I Strongly Recommend** that you also read the on-line documentation for TARTCHEK update, EPICSHOW and PLOTTAB, to get a better overall picture of how this entire code system fits together and can help you. The TART96 on-line documentation is in Microsoft Word 5.1 format and includes black and white as well as color graphic results. Only when you start using the codes in combination will you realize that this is a complete system that can really assist you in your work.

Computer Requirements

Any modern Computer, at Least 8 Megabytes Memory and 20 Megabytes Disk Space.

Background

TART96 is a coupled neutron-photon, 3 Dimensional, combinatorial geometry, Monte Carlo transport code. The original TARTND has been used and distributed from Lawrence Livermore National Laboratory for many years. TART95, released in July 1995, was the first version of the code designed to be used on virtually any computer. TART96 is designed to extend the general utility of the code to more areas of application, by concentrating on improving the physics used by the code. **TART96 completely supersedes all older versions of TART, and it is strongly recommended that users only use the most recent version of TART96 and its data files**.

TART95

The objective of TART95 was to develop a code that is as computer independent as possible. This objective was met by July 1995, when TART95 and its documentation were distributed for general use. At that time TART95 was operational on large mainframe computers, such as CRAY, and workstations, such as: SUN, SGI, HP, DEC Alpha, Meiko, and IBM RISC, as well as IBM-PC. Since that time it has become operational on additional types of computers, such as PowerMAC and even Laptop computers.

TART95 is written in such simple, computer independent FORTRAN, that it can now be easily implemented and used on virtually any computer.

TART96

Once the objectives of TART95 were met work began on TART96. The objective of TART96 is to extend the general utility of the code to more areas of application, by concentrating on improving the physics used by the code.

The most important improvements include,

A new **neutron 650 group treatment** for cross sections over the energy range 10^{-4} eV up to 1 GeV. Older versions of the code used a 175 group treatment from 1.309 10^{-3} eV up to 20 MeV, with most of the groups concentrated at higher energy; this limited accurate use of the code to higher energy applications. In contrast the new 650 group treatment is designed to accurately treat the entire neutron energy range, thereby allowing the code to be used for a wider range of applications. As yet neutron data is only generally available up to 20 MeV, but as soon as higher energy data becomes available TART96 is ready to use it. If you are a fan of the older 175 group treatment, not be worry: TART96 can use either 175 or 650 groups - the choice is yours.

Incorporating the ENDF/B-VI cross sections. Older versions of the code only used the Livermore ENDL library, which is primarily designed for use in high energy applications. In contrast the ENDF/B-VI data is designed for general use at all energies. Therefore using this data allows the code to be accurately used in a wider range of applications. If you are a fan of the older ENDL data, not be worry: TART96 can use either ENDL or ENDF/B-VI - the choice is yours.

Improved Thermal Scattering treatment. The major advantages of the new thermal scattering treatment include: improved accuracy of sampling, and greatly improved speed of execution.

General Improvements. TART95 is based on the older TARTND code, but required massive changes to the code to make it computer independent. As such there were bound to be some growing pains with this essentially new code. Over the last year and a half, feedback from the many code users has led to general improvements in the code, both in terms of locating and correcting problem areas, as well as in adding and improving code options to meet the needs of users.

Further Improvements in Computer Independence. TART95 was implemented on a variety of computers, but it required the use of a few routines that varied from one computer to another. On the basis of user feedback, most of this remaining computer dependence has now been eliminated, and TART96 is now so computer independent that it is almost trivial to implement it on any new type of computer that comes along.

Still be to incorporated in future versions of this code is a new **photon 801 point treatment** for cross sections over the energy range 10 eV up to 1 GeV. Older versions of the code used a 176 point treatment from 100 eV up to 30 MeV, with most of the points concentrated at higher energy; this limited accurate use of the code to higher energy

applications. As with the 650 neutron treatment, this new treatment of the photon cross sections is designed to accurately treat the entire energy range, allowing the code to be used for a wider range of applications.

Running Time

The below table presents results obtained using the TART 68 fast critical assembly benchmark problems. All 68 fast criticality problems were run on each computer. This table summarizes timing results for the older TARTND code, that only runs on CRAY computers, as well as TART95 and TART96 on a variety of computers.

Code	Computer	Running Time (Seconds)	Ratio to TARTNP CRAY-YMP	
TARTNP	CRAY-YMP	5396	1.0	YMP
TART95	DEC-Alpha	1045	0.19	800 Model 5/300
TART95	IBM-PC	1260	0.23	PentiumPro/200
TART95	HP-735	2237	0.41	735/125 MHz
TART95	CRAY-YMP	4912	0.91	YMP
TART95	IBM-RISC	7843	1.45	RS-6000
TART95	Power-MAC	7902	1.46	7500/100 MHz
TART95	SUN	8292	1.54	SPARC 20
TART95	CRAY-J90	9678	1.79	J90
TART95	Meiko	9993	1.85	CS-2/66
TART95	SGI	10157	1.88	R4000/100 MHz
TART95	IBM-PC	18437	3.41	486DX2/66 MHz
TART96	DEC-Alpha	887	0.16	800 Model 5/300
TART96	IBM-PC	1104	0.20	PentiumPro/200
TART96	HP-735	1932	0.35	735/125 MHz
TART96	IBM-PC LapTop	2791	0.52	LapTop/133 MHz
TART96	CRAY-YMP	4502	0.83	YMP
TART96	SUN	5881	1.09	Sparc-20
TART96	Power-MAC	5912	1.09	7500/100 MHz
TART96	IBM-RISC	6404	1.19	RS-6000
TART96	Meiko	7843	1.45	CS-2/66
TART96	CRAY-J90	8103	1.50	J90
TART96	SGI	8633	1.60	R4000/100 MHz
TART96	IBM-PC	17093	3.16	486DX2/66 MHz

When we compare the three codes all run on the same CRAY-YMP, we find that compared to the older TARTND code, TART95 is about 9 % faster, and TART96 is 17 % faster. So that not only has TART96 been extended for more general uses, these extensions were accomplished with no lose in running time efficiency, i.e., TART96 is actually faster than TART95.

You should also note the advantage of TART95 and TART96 over the older TARTND in terms of their ability to be used on virtually any computer. For example, even a Laptop computer runs TART96 about twice as fast as TARTND on a CRAY-YMP, and on a basically $ 3,000 IBM-PC Pentium Pro 200, TART96 runs almost five times faster than TARTND does on a multi-million dollar CRAY-YMP. Consider that since this $ 3,000 computer, has run 68 separate criticality problems in a total of 1104 seconds, it means **on average each criticality problem is completed in less than 17 seconds!!! It boggles the mind.**

What Code should you be using?

TART96 completely supersedes all older versions of TART, and it is strongly recommended that users only use the most recent version of TART96 and its data files. How do you know if you have the most recent version of the code and its data files? As soon as the code starts to run it identifies the version you are running and the dates of its data files. Below is the beginning of the code output report. Note, the code version: **TART 96-4, Sept '96**, and the date of all the data files: **10/31/95**. If you are using an older version of the code or its data files, it is strongly recommended that you contact me to obtain the most up-to-date code and data.

```
 TART96 - Neutron-Photon Monte Carlo Transport (TART 96-4, Sept '96)
```

```
 I/O Files Opened for Entire Run
=============================================================================
 Definition                                  Filename  Unit  Date
=============================================================================
 TART Input Parameters.....................TART.IN      2
 TART Output Listing.......................TART.OUT     3
 Neutron Interaction Data File.............TARTND       7  10/31/95
 Photon Interaction Data File..............GAMDAT       8  10/31/95
 Neutron Induced Photon Production File...TARTPPD      9  10/31/95
 Multi-Band Parameter File................NEWCROSS    10  10/31/95

 Neutron Interaction Data.  175 Groups 1.3068D-09 to 2.0000D+01 MeV
 Photon Interaction Data..  176 Points 1.0000D-04 to 3.0000D+01 MeV
```

Utility Codes

In addition to the TART96 code you should also be aware of the utility codes distributed with TART96; of particular note is **TARTCHEK**. One of the most difficult tasks that you will face in using any 3-D combinatorial Monte Carlo code is to correctly define input parameters for the code, particularly to correctly define geometry. This is what **TARTCHEK** is designed to help you with. It is an interactive graphics code that will allow you to view and check your input parameters before you run **TART96**. Even we so called "experts" on **TART96** find that using **TARTCHEK** can greatly reduce the amount of time that we have to spend on input preparation, and even what is more important,

greatly improve the reliability of our input parameters. **TARTCHEK** can also help you analyze results by overlaying flux or energy deposition on your geometry. If you are not using **TARTCHEK** you are only making your job more difficult, and you don't know what you are missing.

Documentation

Although TART95 has been completely superseded by TART96, the most complete documentation for TART96 is still,

TART95: A Coupled Neutron-Photon Monte Carlo Transport Code, Lawrence Livermore National Laboratory, UCRL-MA-121319, July 4, 1996, by D. E. Cullen, A.L. Edwards and E.F. Plechaty

At Livermore, for copies of this report, contact me. Outside of Livermore, contact your local computer code center; see below.

Additional Documentation

The TART96 system also includes documentation for TARTCHEK, EPICSHOW, PLOTTAB and EDITOR. To fully appreciate the features of the overall system you are encouraged to also read the documentation for these codes to see examples of how the codes can be used in combination.

TART95 documentation is now available on-line on the Web at,

http:/www-phys.llnl.gov/N_Div/TART

All of the TART96 documentation will soon be available at this Website.

Availability

At Livermore, for copies of the system, contact me. Outside of Livermore, contact your local computer code center - within the United States, the Radiation Shielding Information Center (RSIC), Oak Ridge National Laboratory (e. mail: jib@ornl.gov), outside of the United States, the Nuclear Energy Agency/Data Bank (NEA/DB), Paris, France (e. mail: sartori@nea.fr).

Code Installation

The code is distributed with detailed instructions concerning installation and testing of the code. These instructions are periodically updated for distribution with the code, to insure that the instructions are as up-to-date as possible, and exactly correspond to the version of the code that you will be implementing and using. As such, installation instructions will not be included here.

When you receive this code system you will find it arranged in a file directory structure. At each level of the directory you will find a file named **README**. These are plain text files that can be printed or read using any text editor. Be sure that you read all such files as you proceed with installation and testing.